Climate Change and The Role of Renewable Energy and Energy Efficiency

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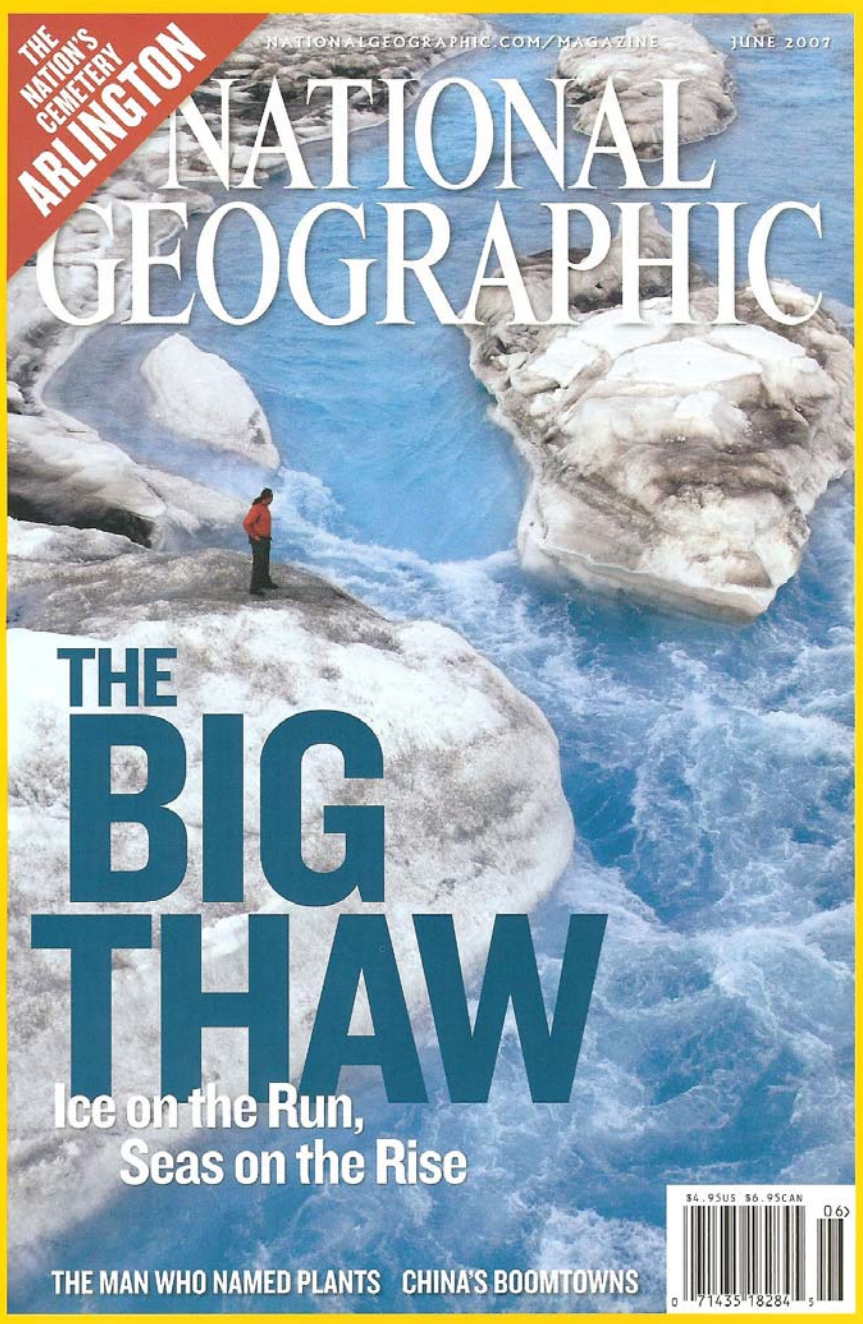
American Solar Energy Society
November 30, 2007

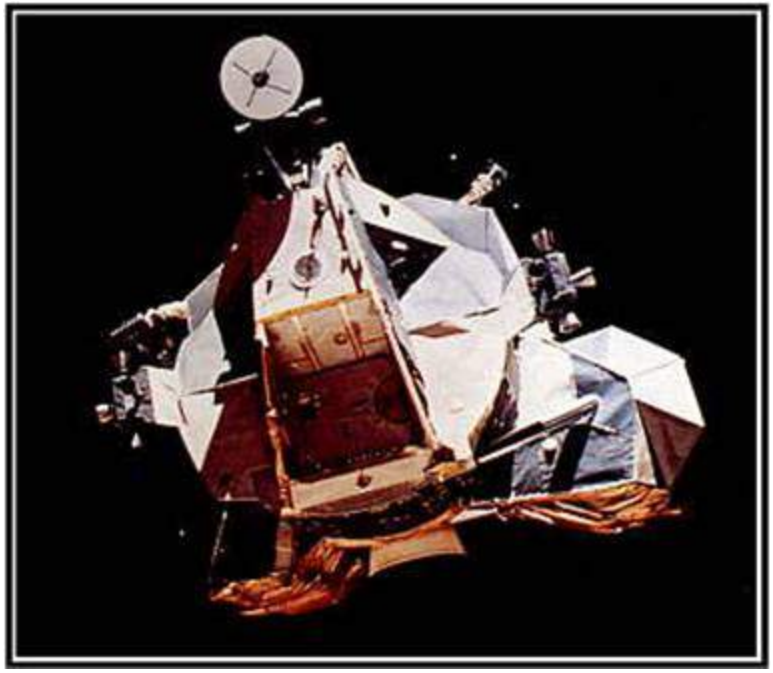
March 31, 2006 Headline:

Caribbean coral suffers record die-off

World's coral reef loss 'an underwater holocaust'


THE NATION'S CEMETERY
ARLINGTON
NATIONALGEOGRAPHIC.COM/MAGAZINE
JUNE 2007
NATIONAL GEOGRAPHIC
THE BIG THAW
Ice on the Run, Seas on the Rise
$4.95US $6.95CAN
06
THE MAN WHO NAMED PLANTS
CHINA'S BOOMTOWNS

“Houston, we have a problem.”



Key Options

- Energy Efficiency
- Renewable Energy
- Coal with carbon capture and storage
- Nuclear power

American Solar Energy Society
WORKING TOWARD A SUSTAINABLE ENERGY FUTURE

SOLAR 2006, Denver
"Renewable Energy: Key to Climate Recovery"

Areas Studied

- Energy Efficiency (Buildings, Transportation, Industry)
- Concentrating Solar Power (CSP)
- Photovoltaics (PV)
- Wind Power
- Biofuels
- Biomass
- Geothermal

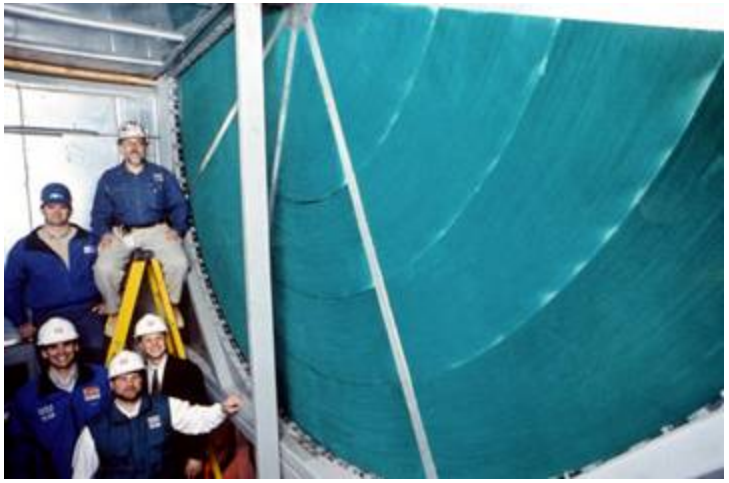
Total savings needed by 2030: ~1,200 MtC/yr

Energy Efficiency

- ***Buildings*** (40%) – envelope design, daylighting, better lights, building and appliance efficiency standards
- ***Transportation*** (30%) - lighter weight vehicles, public transportation, better propulsion, PHEVs
- ***Industry*** (30%) – heat recovery, better motors, CHP

Energy Efficiency Savings

- Electricity: 20% savings off 2030 projection
  218 MtC/yr, 0 – 4 ¢/kWh
- Oil: 344 MtC/yr, $5 - $30/bbl
- Gas: 126 MtC/yr, $0 - $3/MBtu



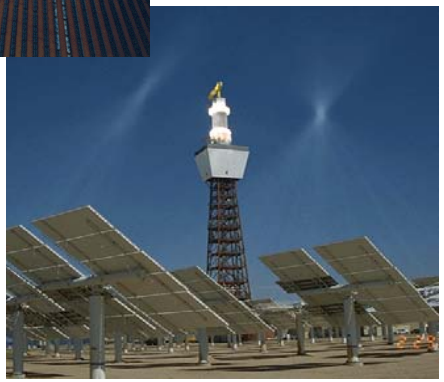
Key Sources
Electricity: *Scenarios for a Clean Energy Future*
Oil & Gas: *Winning the Oil End Game*

Savings: 688 MtC/yr

Concentrating Solar Power (CSP)

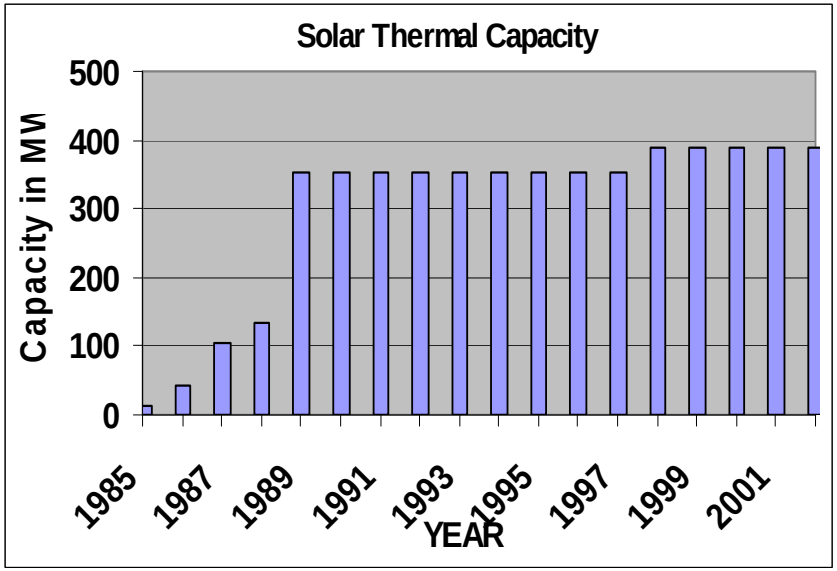
CSP Technologies

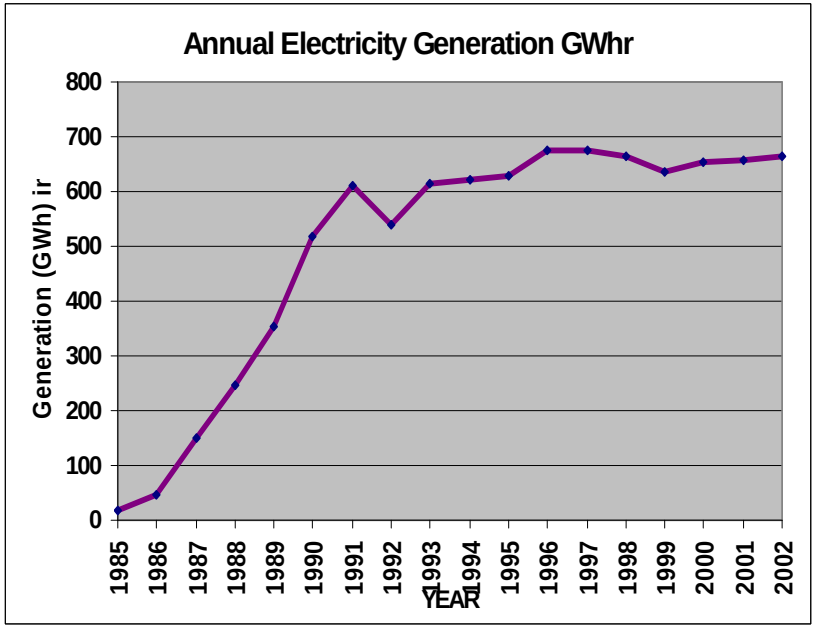
- Dispatchable Generation
  - Parabolic trough
  - Power tower



- Non-Dispatchable Generation
  - Dish/Engine
  - Concentrating PV

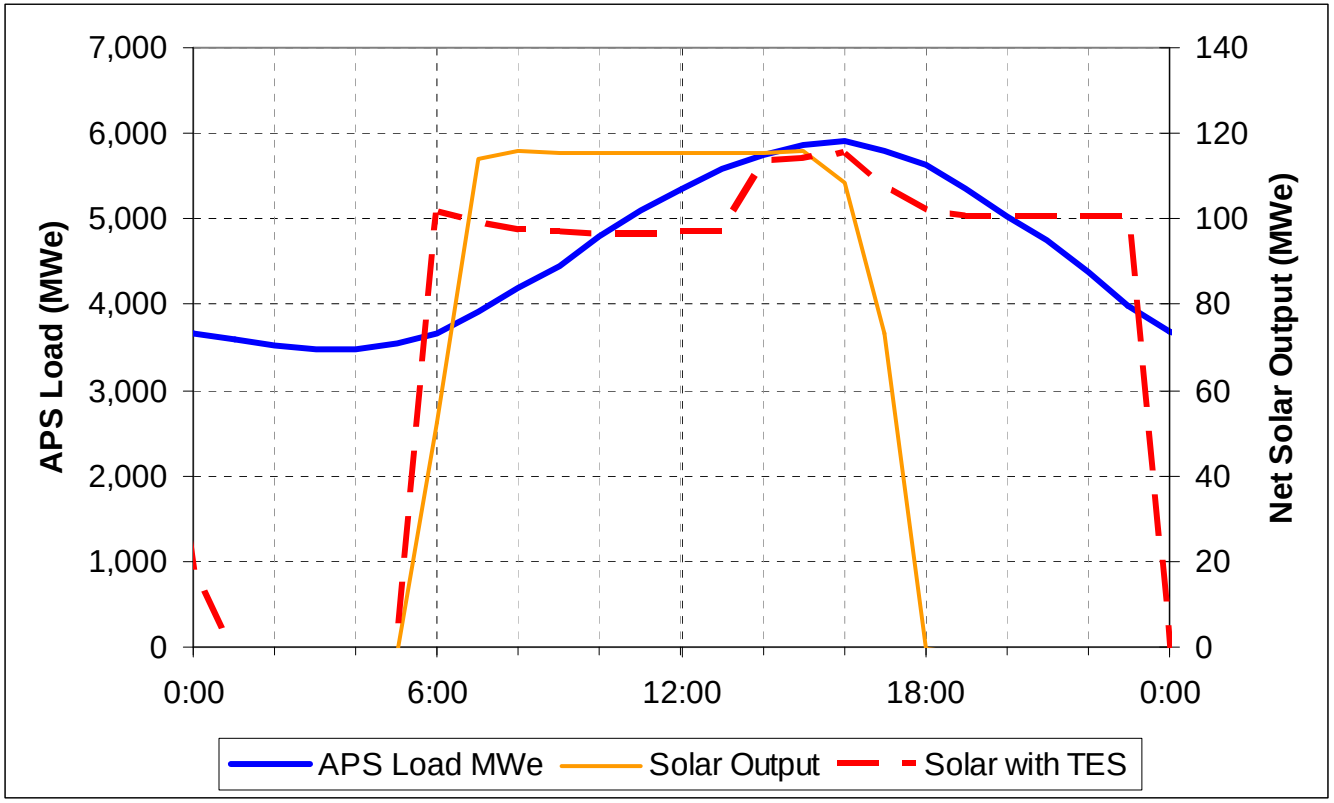
Solar Electric Generation Stations (SEGS) Deployment & Production 1985 - 2002



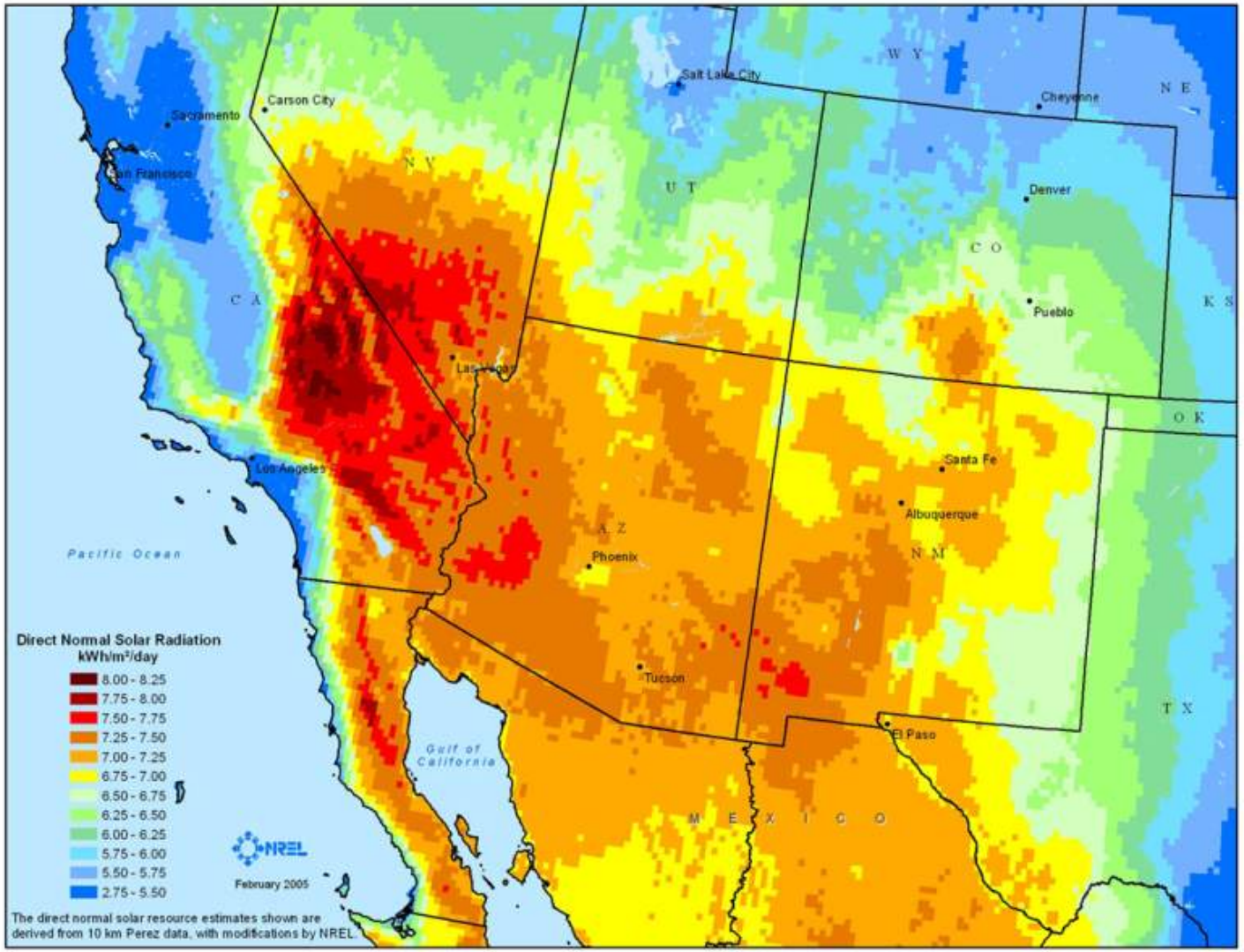


Parabolic Trough Output Profile Summer Day

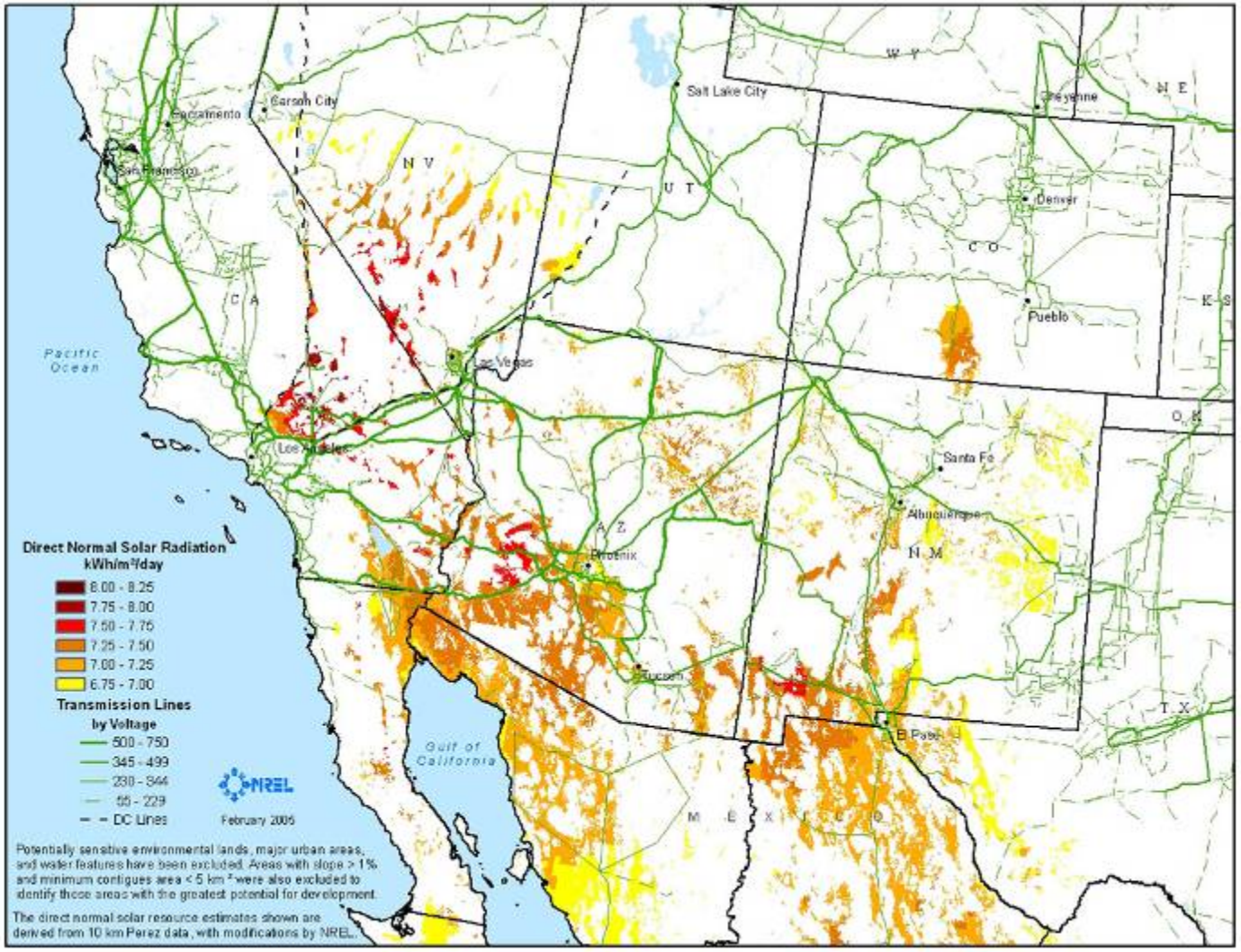
July 8, 2002 - Actual system load, modeled solar output based on actual DNI



CSP Resource



Southwest Solar Resources (With all Filters)
Result: 7,000 GW (7X U.S. capacity)!



Source: Western Governors' Association study

Deployment of 80,000 MW of CSP

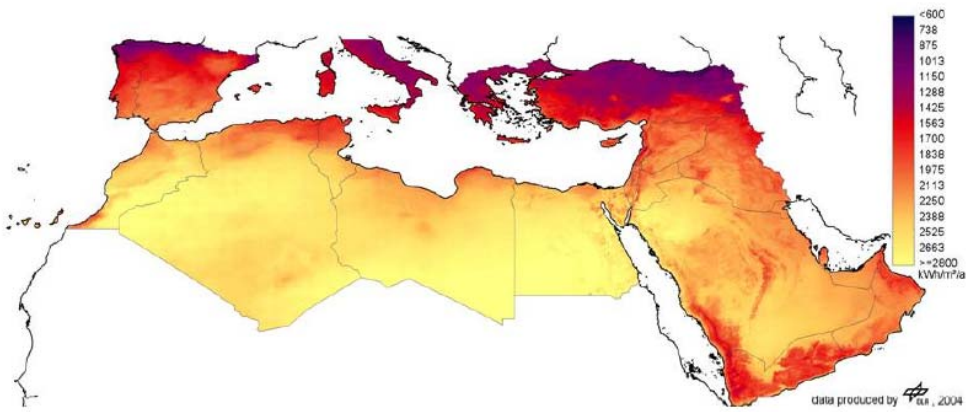
Recent and Planned U.S. CSP Projects

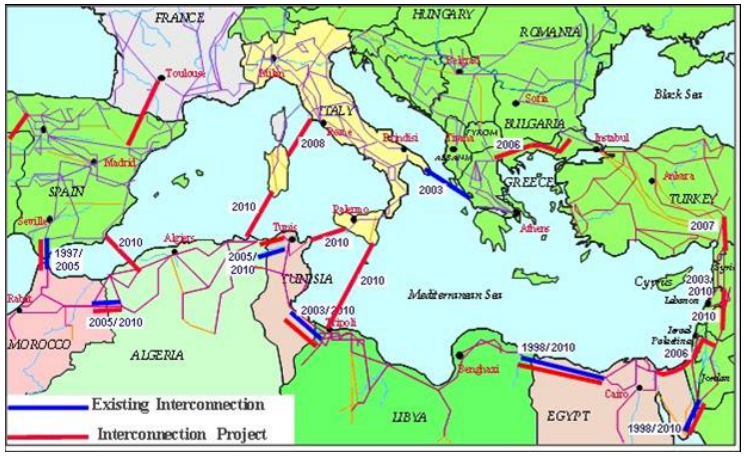
U.S. projects: enabled by 30% investment tax credit and State renewable portfolio standards

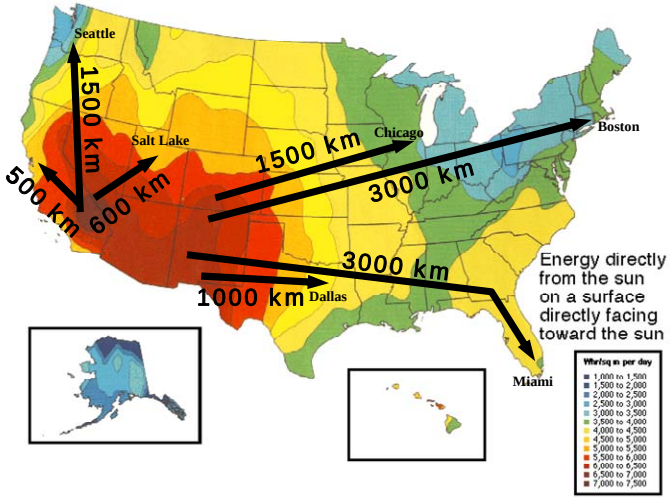
State	RPS Requirement
Arizona	15% by 2025
California	20% by 2010
Colorado	20% by 2020
Nevada	20% by 2015, 5% Solar
New Mexico	20% by 2015
Texas	5,880MW (~4.2%) by 2015

Utility/State	Capacity (MW)	Technology - Status
Arizona Public Service (APS)	1	Trough – completed and in operation 2006 (Acciona)
Nevada Power	64	Trough – completed and in operation June 2007 (Acciona)
Southern Cal Edison	500-850	Dish – signed power purchase agreement (SES)
San Diego Gas & Electric	300-900	Dish – signed power purchase agreement (SES)
Pacific Gas & Electric	550	Trough – signed power purchase agreement (Solel)
Pacific Gas & Electric	500	Tower – MOU signed (Bright Source)
SW Utility joint venture (APS)	Est. 250	TBD – multiple expressions of interest submitted
New Mexico Utility Joint Venture	50-500	TBD – initial stages

Long Distance Transmission







"Concentrating Solar Power for the Mediterranean Region," German Aerospace Center (DLR), 2005

CSP Savings

- Dispatchable power with 6 hr of storage
- 80,000 MW, 6 to 13¢/kWh

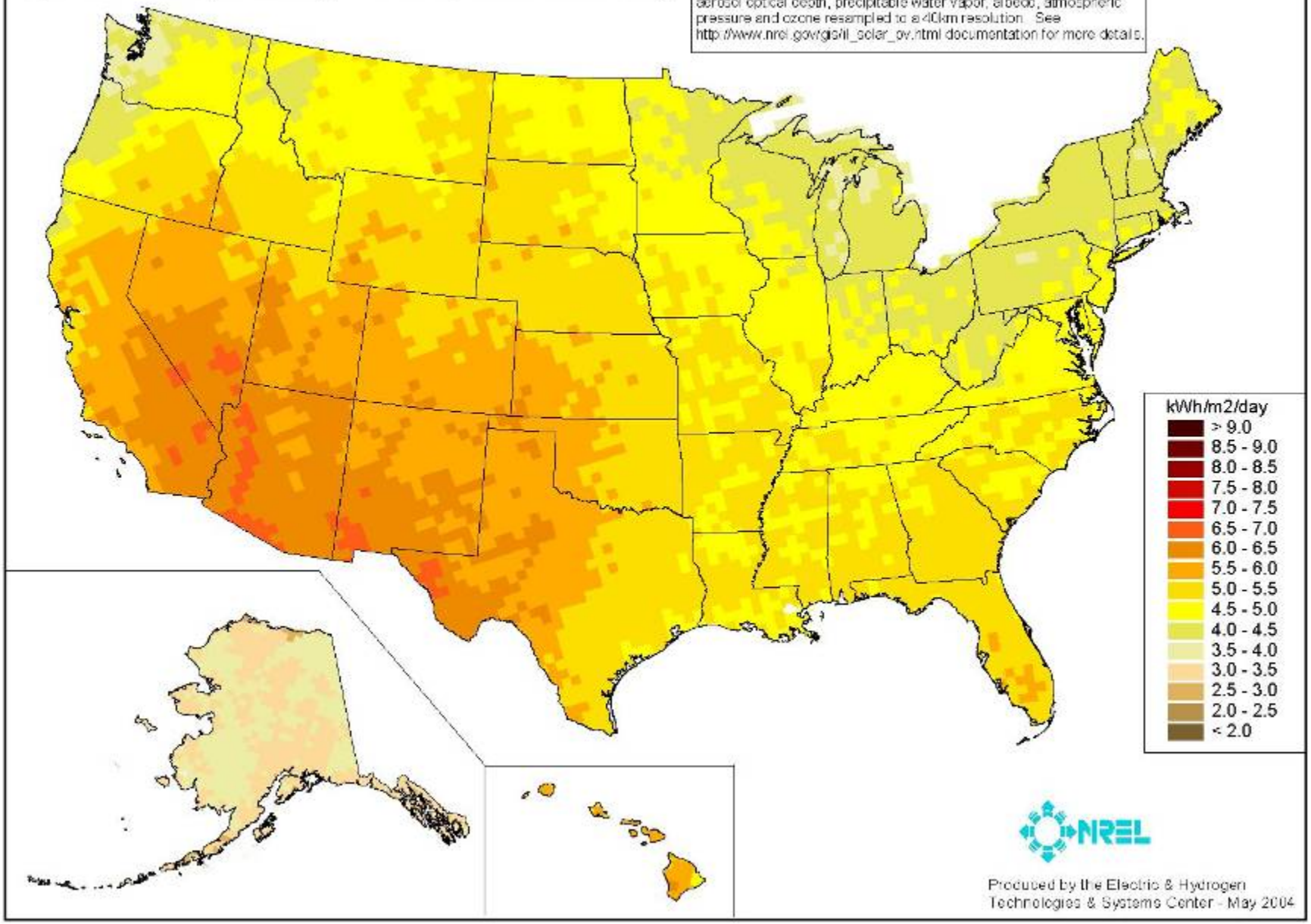
Savings: 63 MtC/yr

Photovoltaics (PV)

PV Solar Radiation
(Flat Plate, Facing South, Latitude Tilt)

Annual

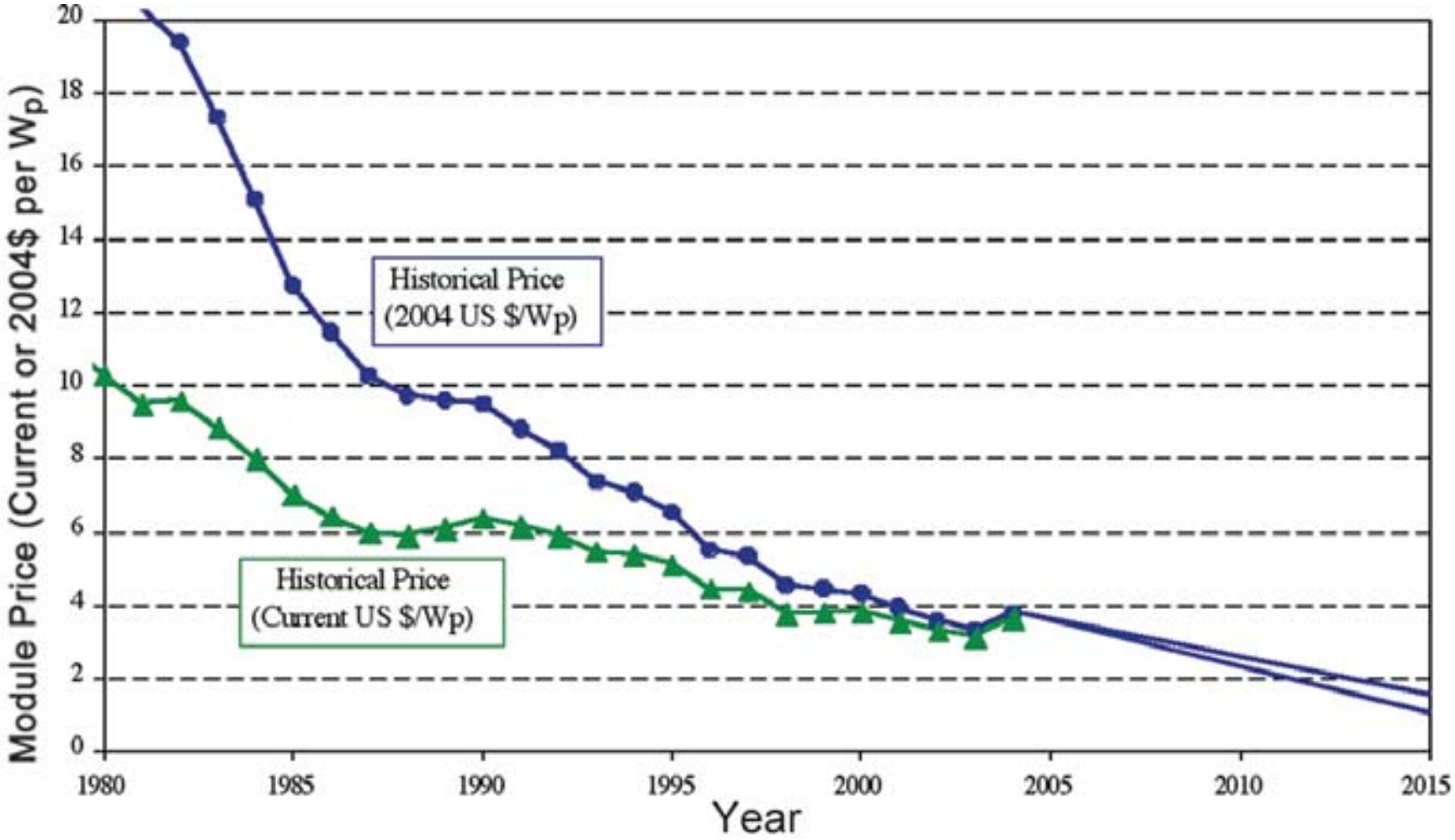
Model estimates of monthly average daily total radiation using inputs derived from satellite and/or surface observations of cloud cover, aerosol optical depth, precipitable water vapor, albedo, atmospheric pressure and ozone resampled to a 40km resolution. See http://www.nrel.gov/gis/ll_solar_pv.html documentation for more details.



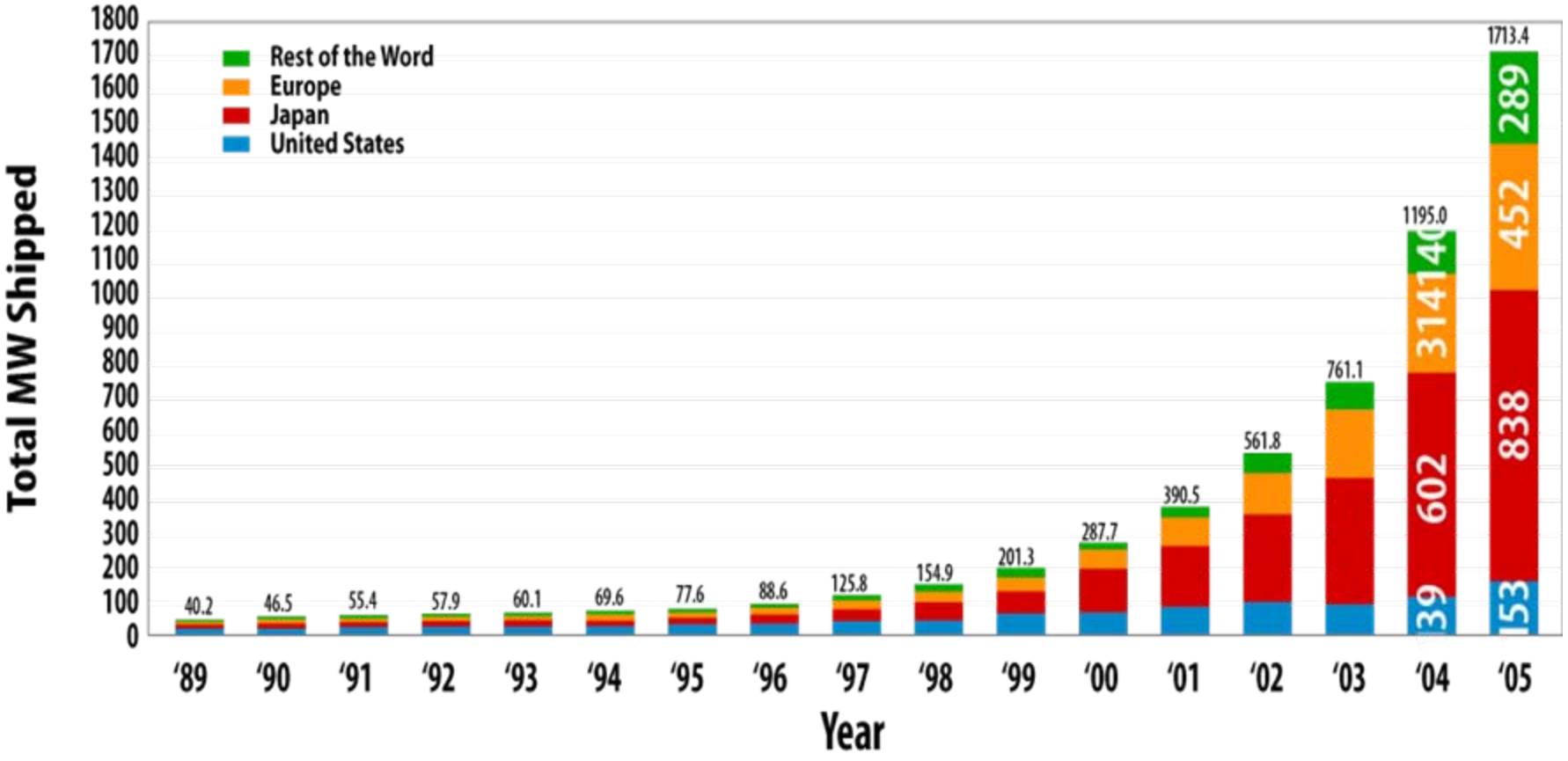
NREL

Produced by the Electric & Hydrogen Technologies & Systems Center - May 2004

PV Module Prices



Worldwide PV Shipments



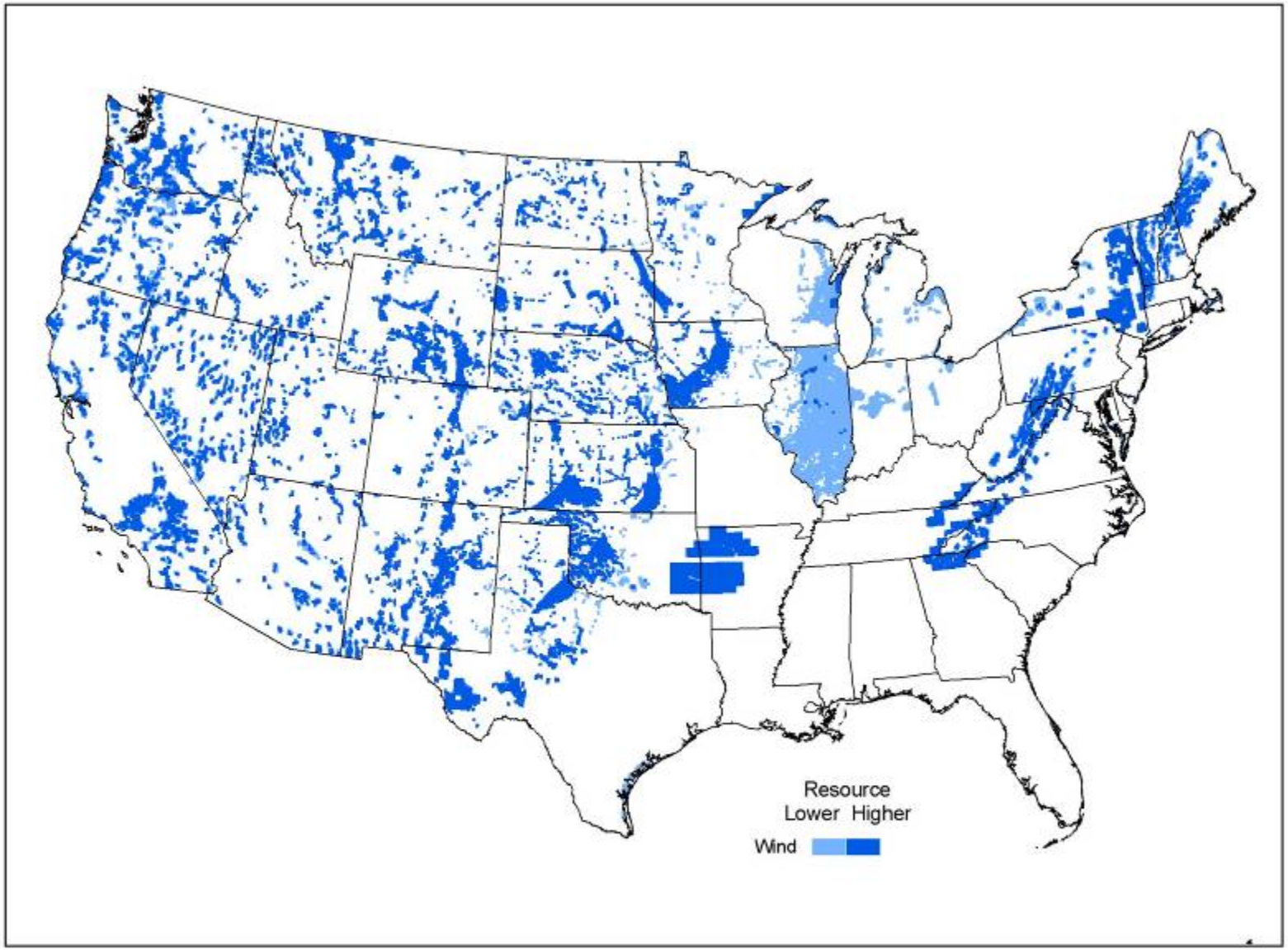
PV Savings

- 200,000 MW_p
- 6 to 28 ¢/kWh (retail)

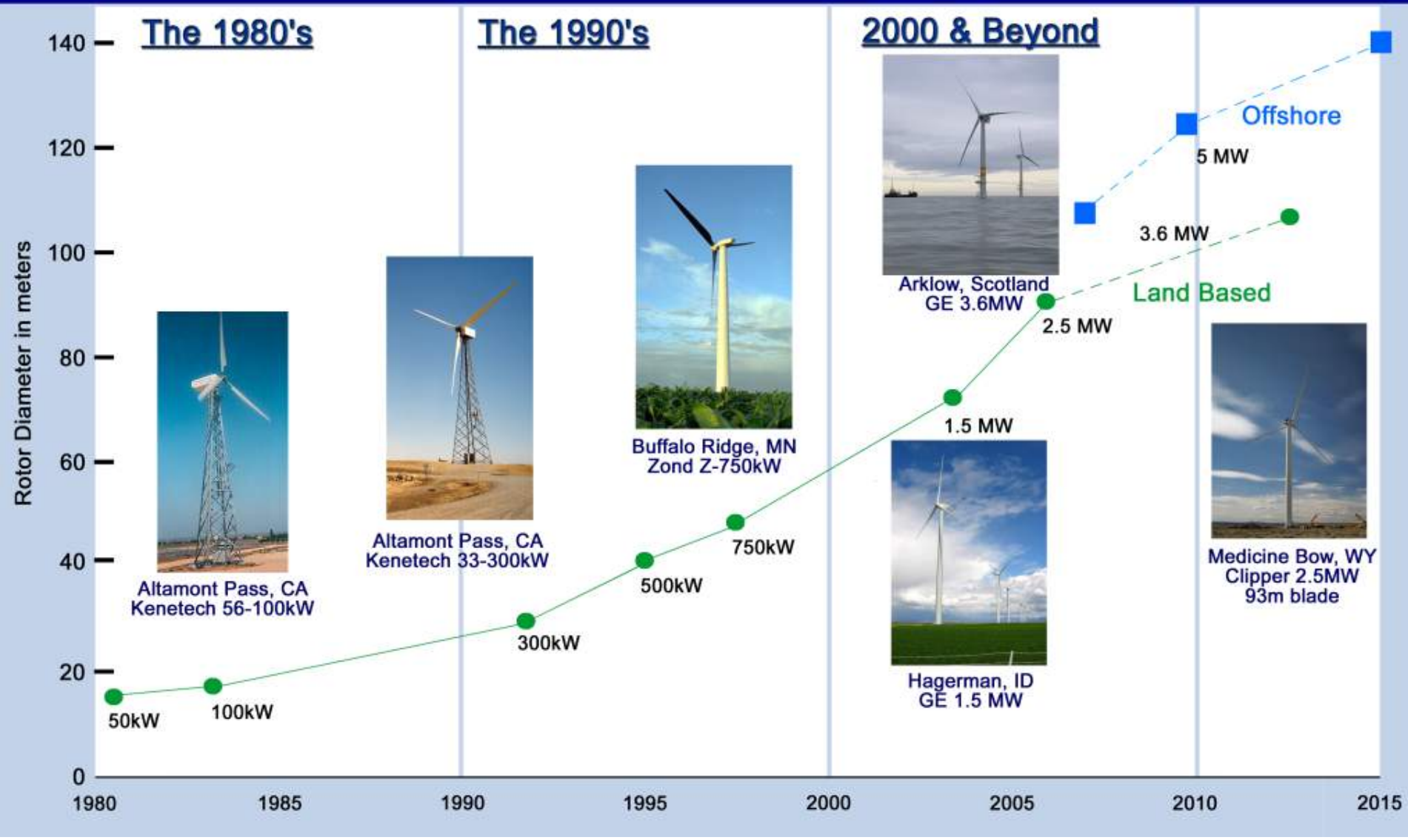
Savings: 63 MtC/yr

Wind

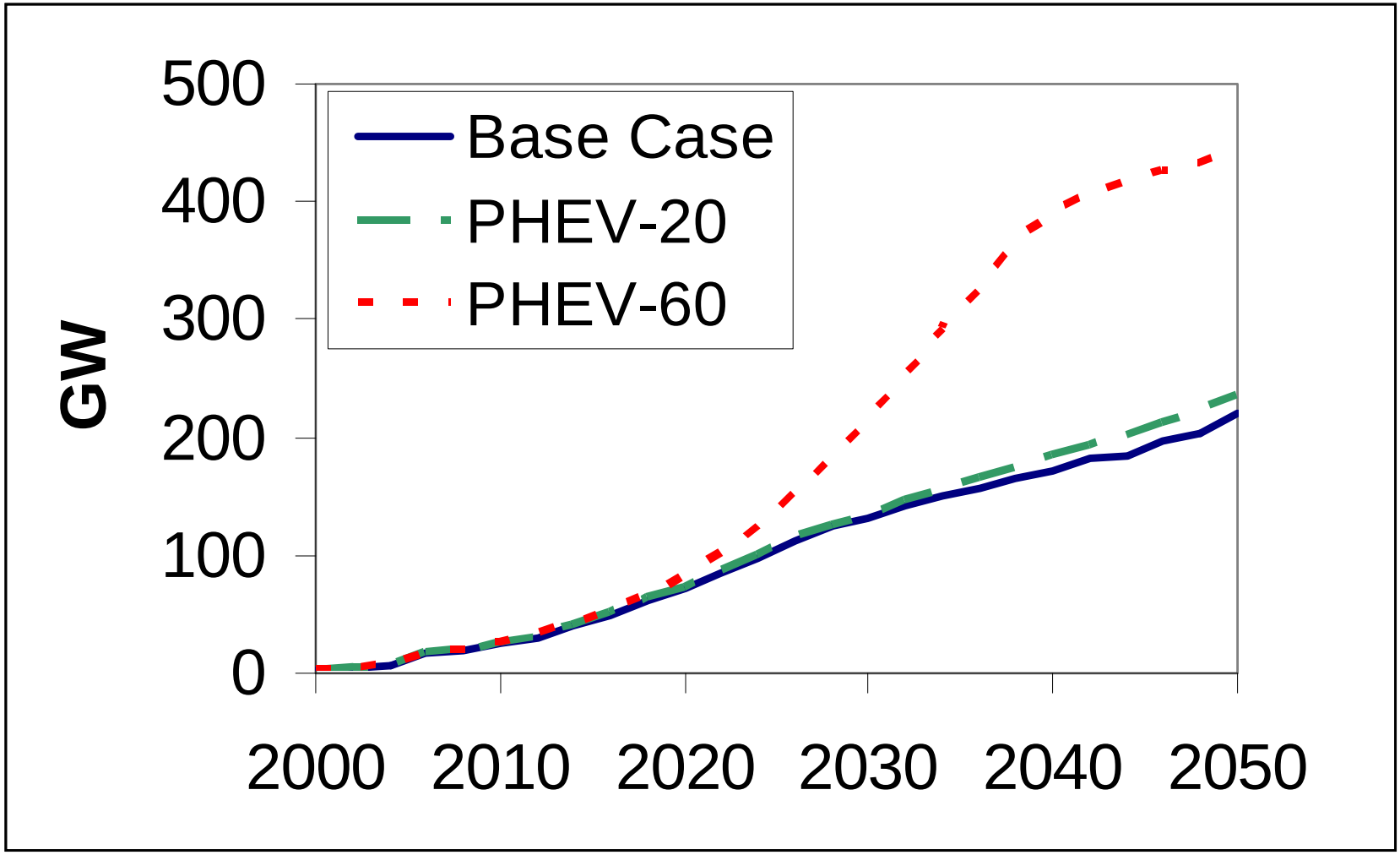
U.S. Wind Resource



Evolution of U.S. Commercial Wind Technology

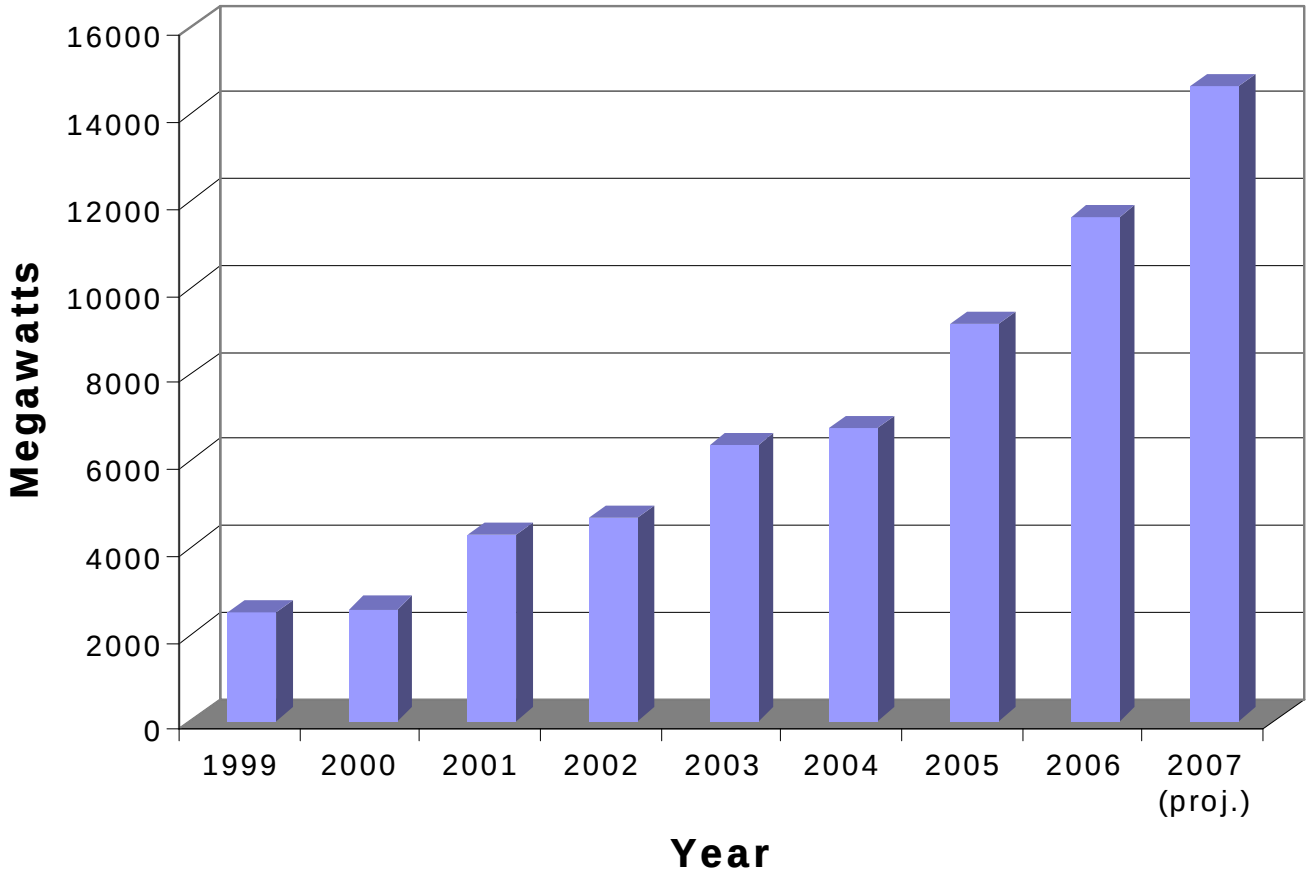


PHEVs* Can Increase Wind Penetration



* Assumes 50% PHEV-V2G penetration by 2050

Growth of U.S. Wind Capacity



Wind Savings

- 20% grid energy, 245,000 MW
- 3 to 7¢/kWh

Savings: 181 MtC/yr

Biomass and Biofuels

Wood chips

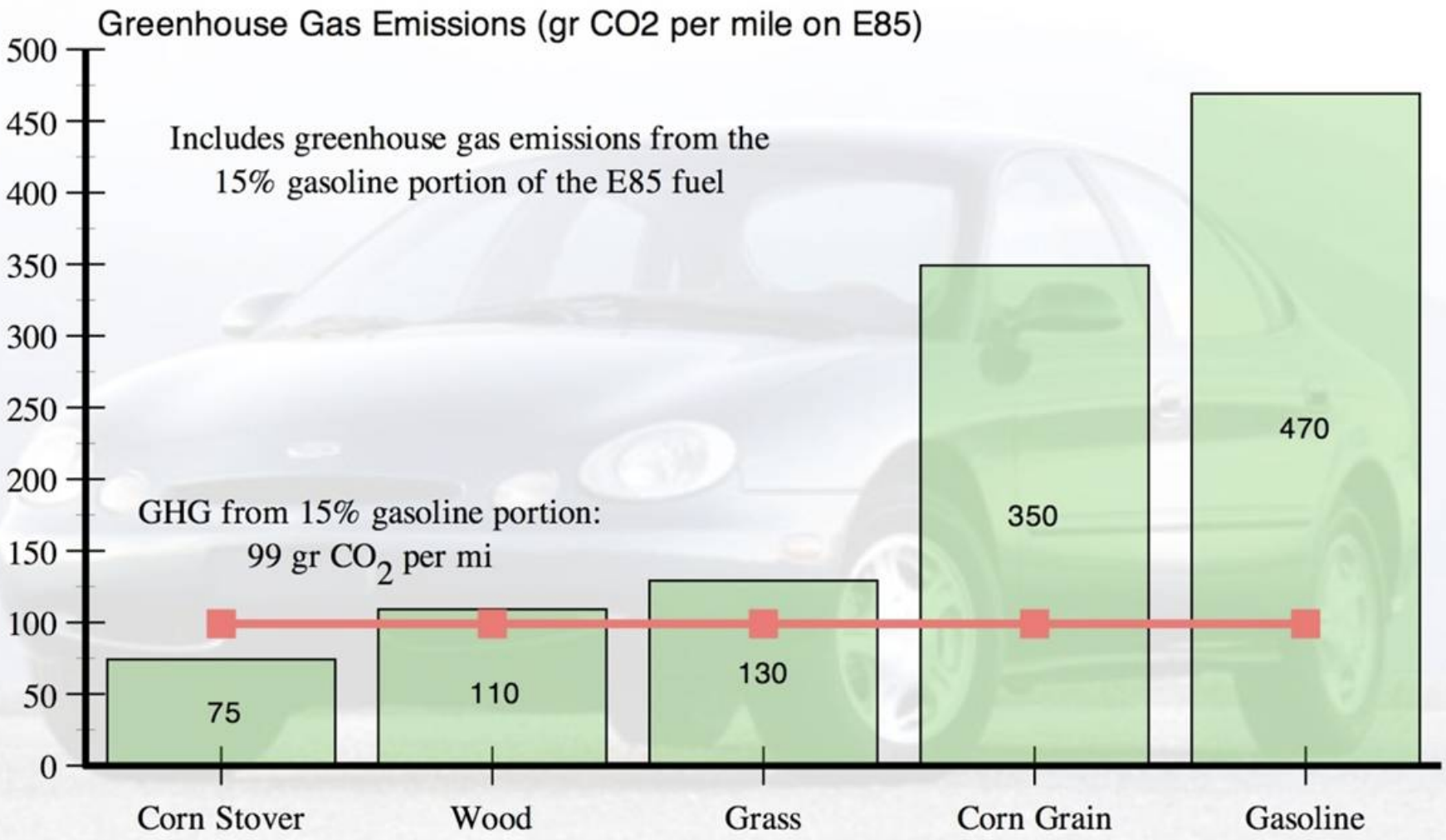
Switch grass

Poplars

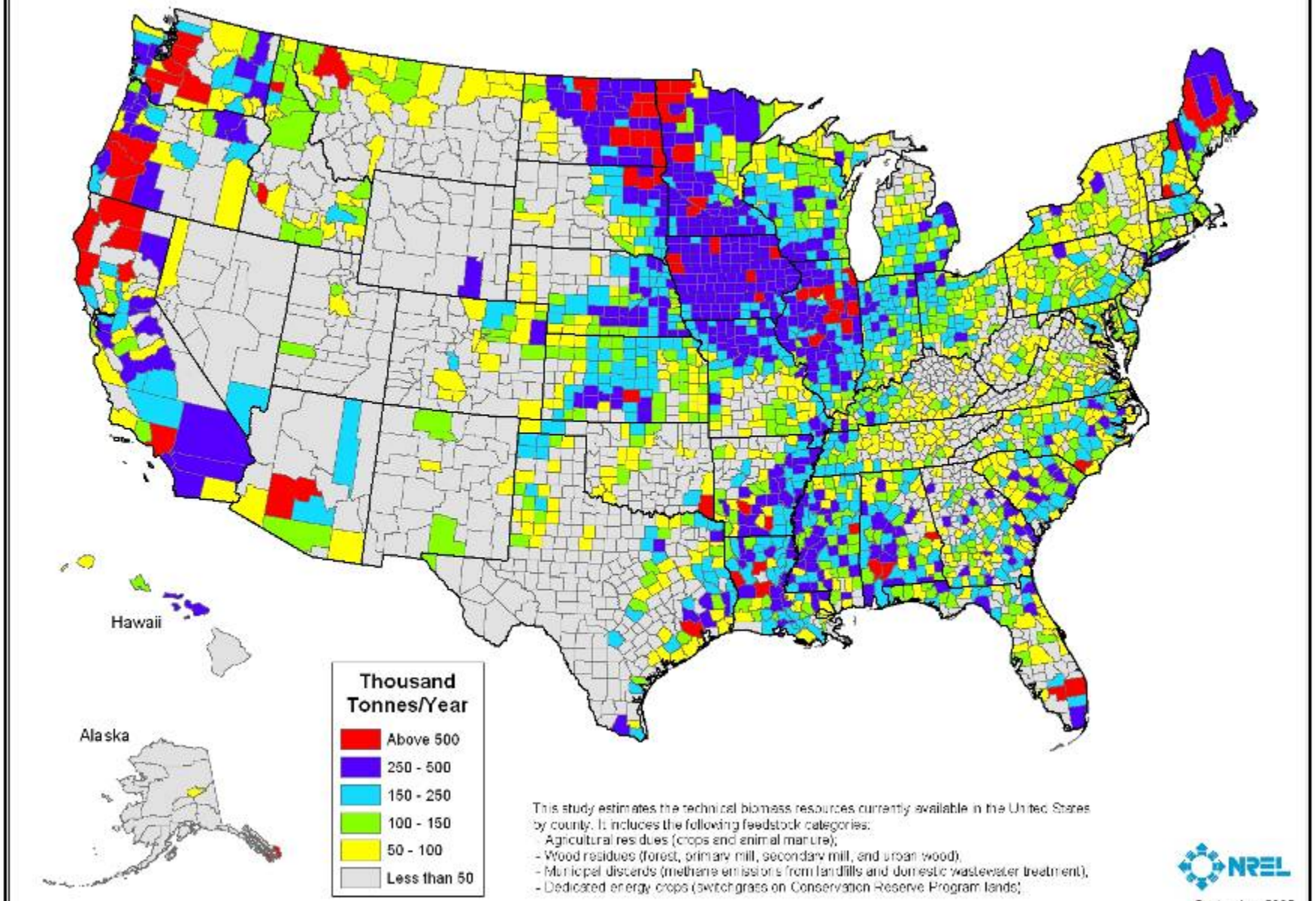
Fats and Oils

Municipal solid waste

Corn Stover


Greenhouse Gas Emissions (gr CO2 per mile on E85)
500
450
400
350
300
250
200
150
100
50
0
Includes greenhouse gas emissions from the
15% gasoline portion of the E85 fuel
GHG from 15% gasoline portion:
99 gr CO_2 per mi
75
110
130
350
470
Corn Stover
Wood
Grass
Corn Grain
Gasoline

Biomass Resources Available in the United States



This study estimates the technical biomass resources currently available in the United States by county. It includes the following feedstock categories:

- Agricultural residues (crops and animal manure);
- Wood residues (forest, primary mill, secondary mill, and urban wood);
- Municipal discards (methane emissions from landfills and domestic wastewater treatment);
- Dedicated energy crops (switchgrass on Conservation Reserve Program lands).

NREL

September 2005

Biofuels Savings

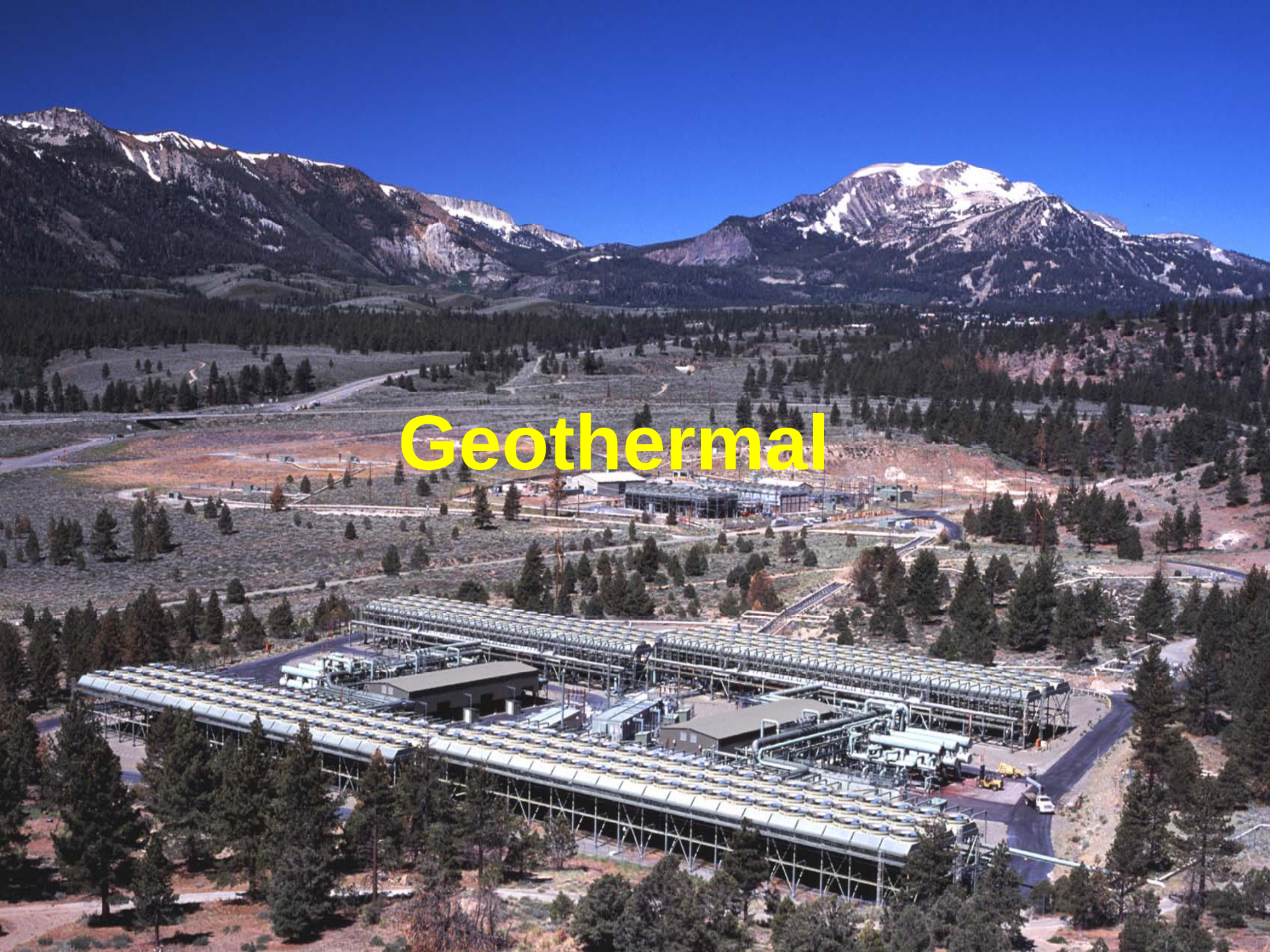
- Ethanol from crop residues & energy crops
- Saves 28 billion gallons of gas in 2030
- $0.90 to $3.75/gal gas equiv.

Savings: 58 MtC/yr

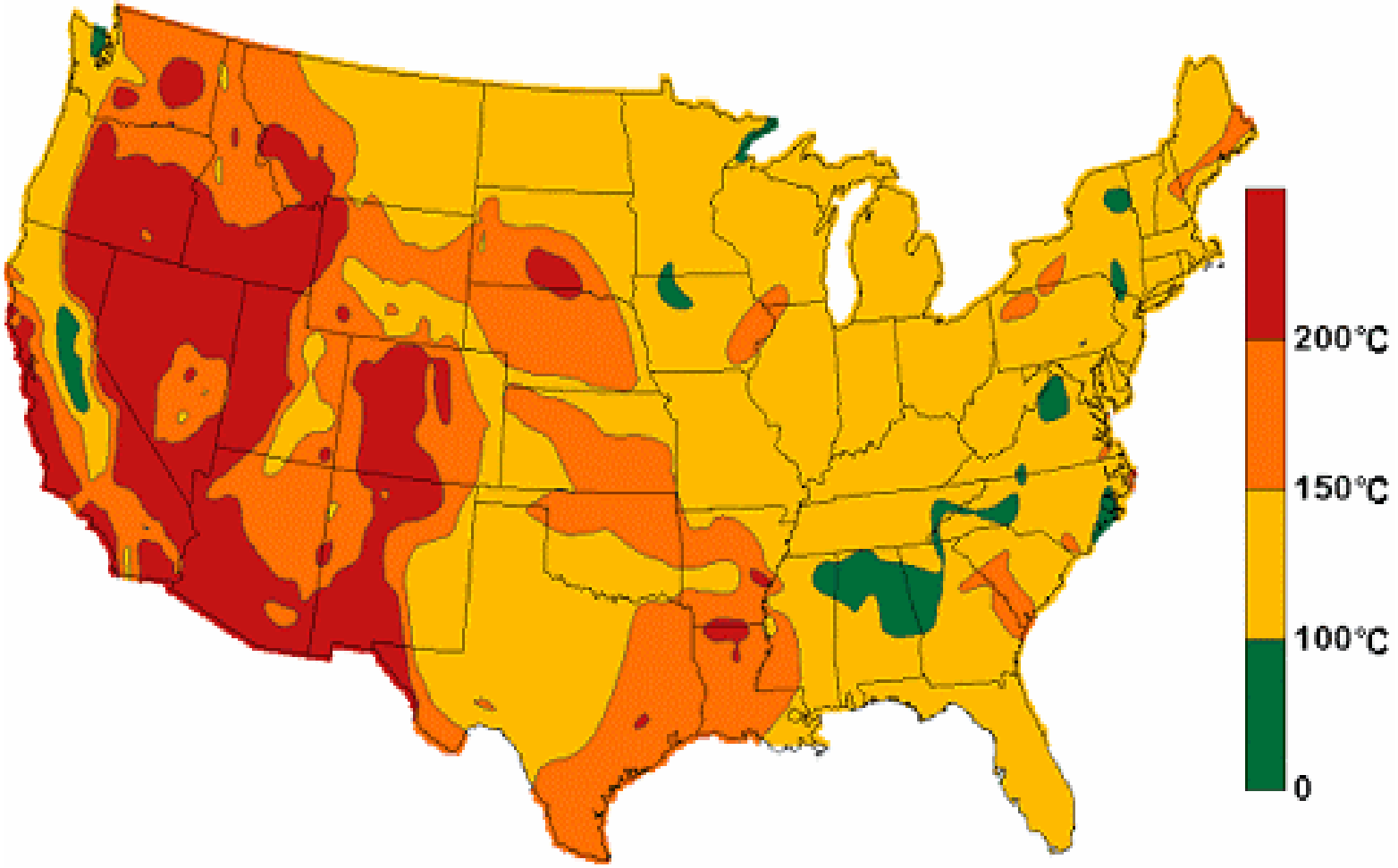
Biomass Power Savings

- Wood residues and municipal discards
- 45,000 MW
- 5 to 8¢/kWh

Savings: 75 MtC/yr


Geothermal

Temperatures at 6 km Depth



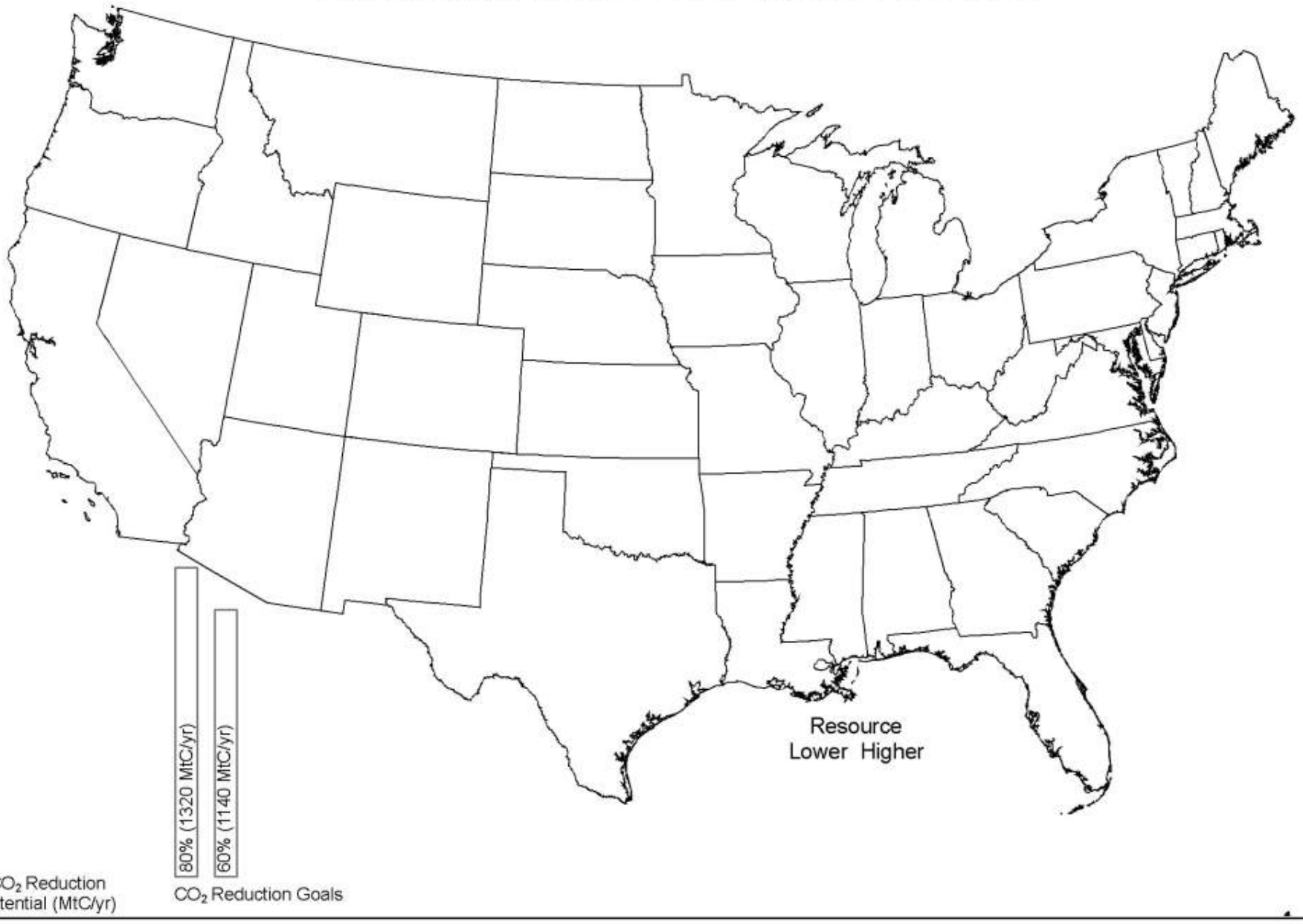
Geothermal Power Savings

- 50,000 MW, 90% capacity factor
- 25% existing resources, 25% expanded, 50% from oil & gas wells
- 5 to 10 ¢/kWh

Savings: 83 MtC/yr

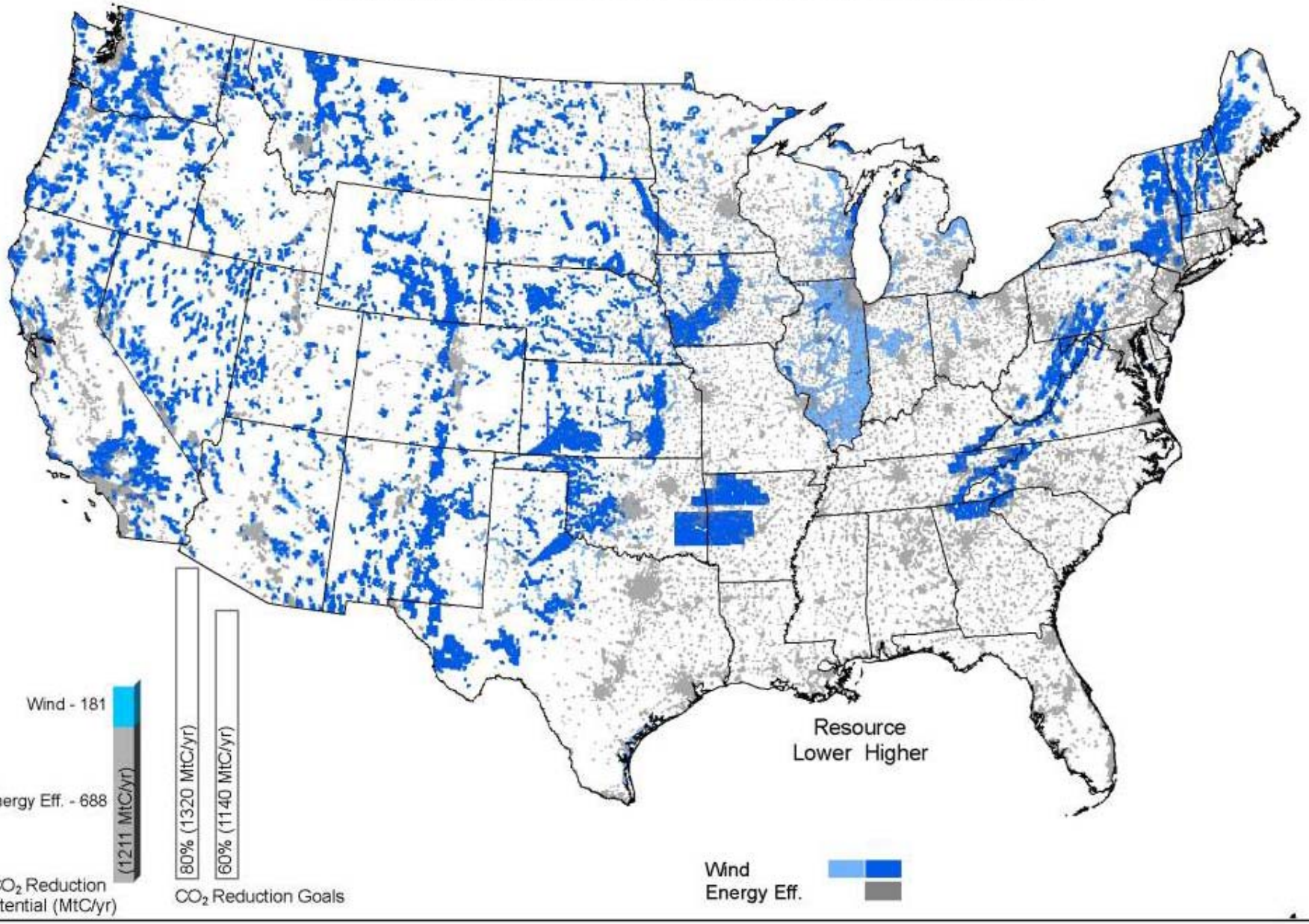
Putting It All Together

Potential Reduction in U.S. Carbon Emissions

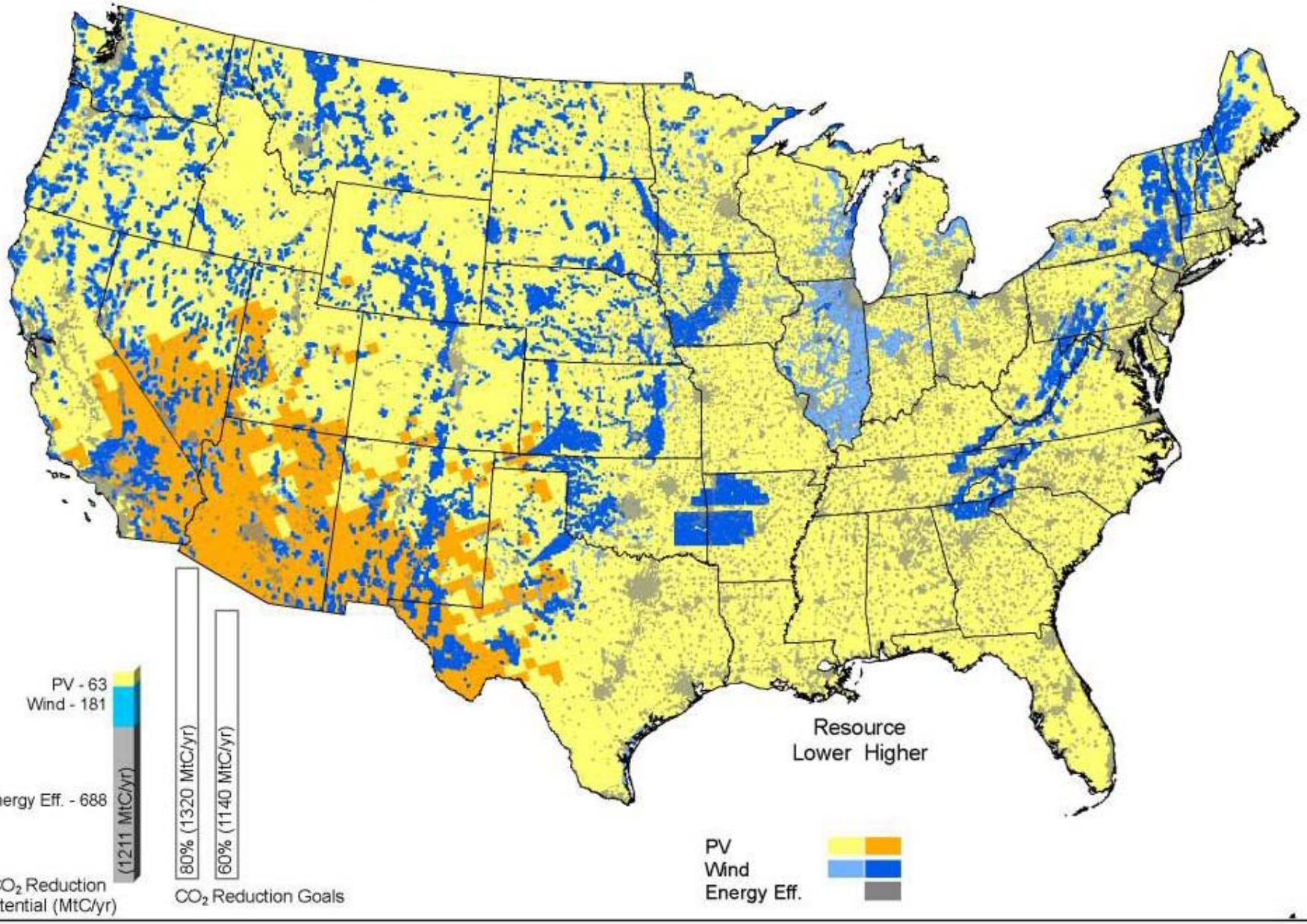


Potential Reduction in U.S. Carbon Emissions

Potential Reduction in U.S. Carbon Emissions



Potential Reduction in U.S. Carbon Emissions



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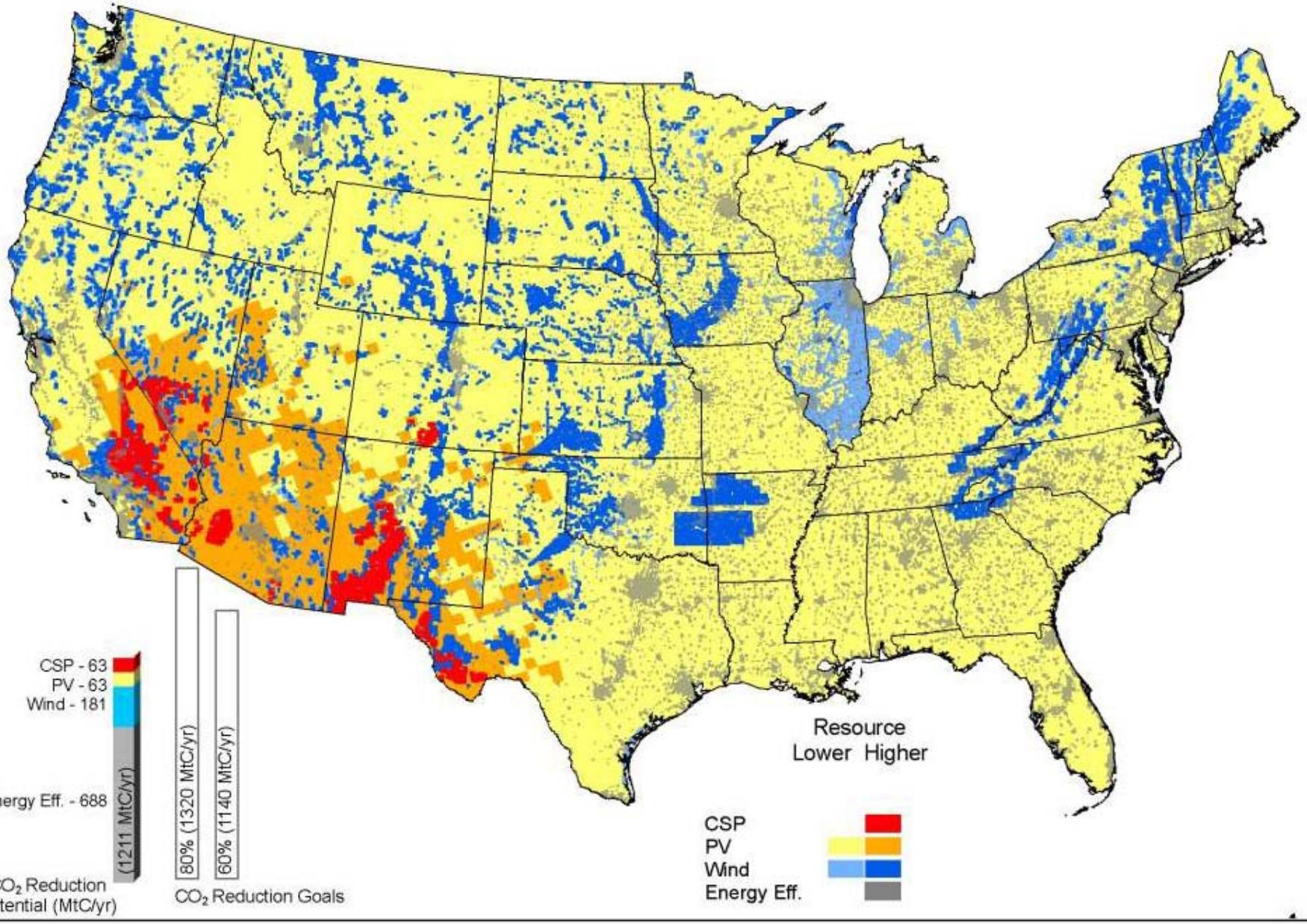

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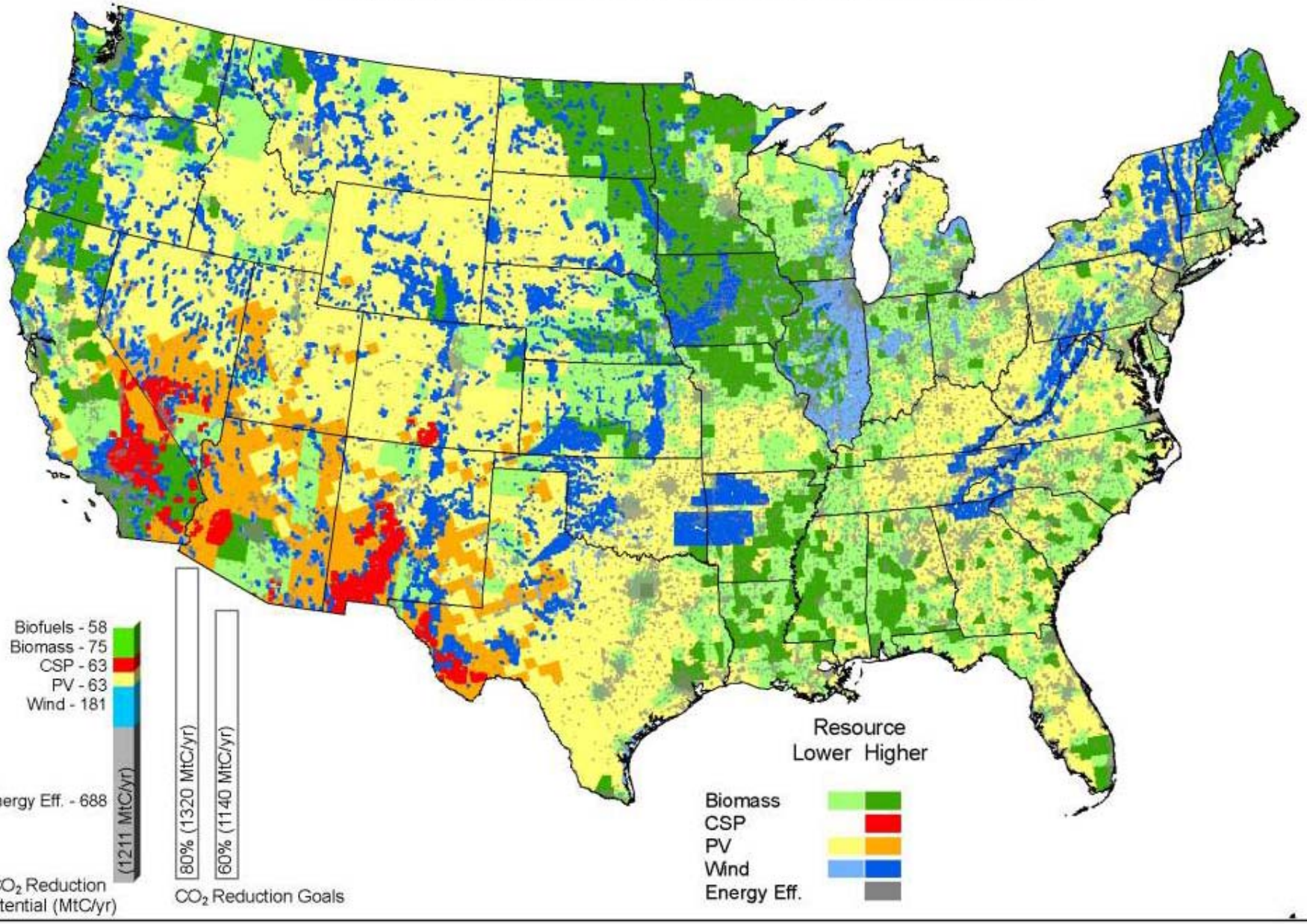

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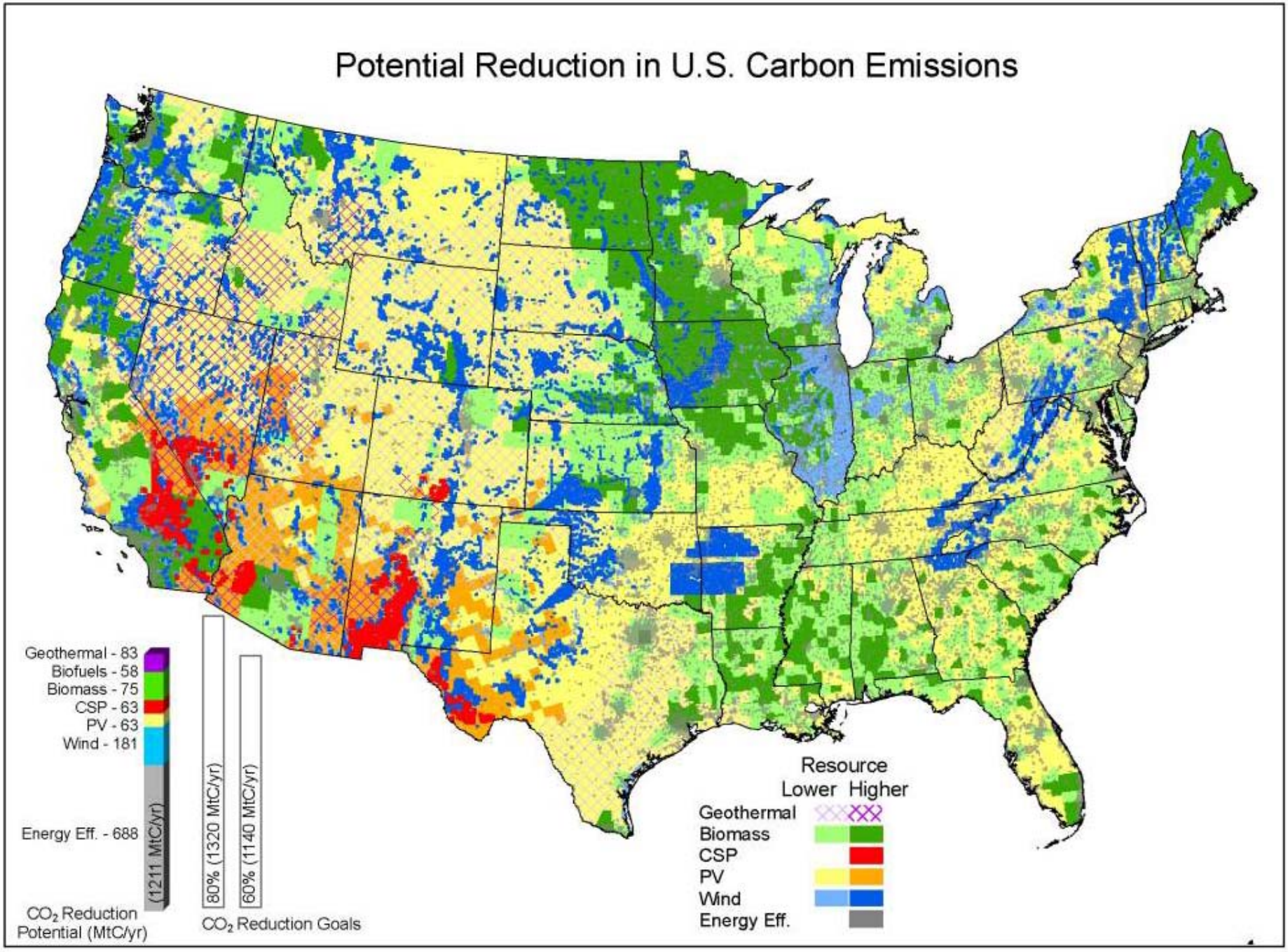
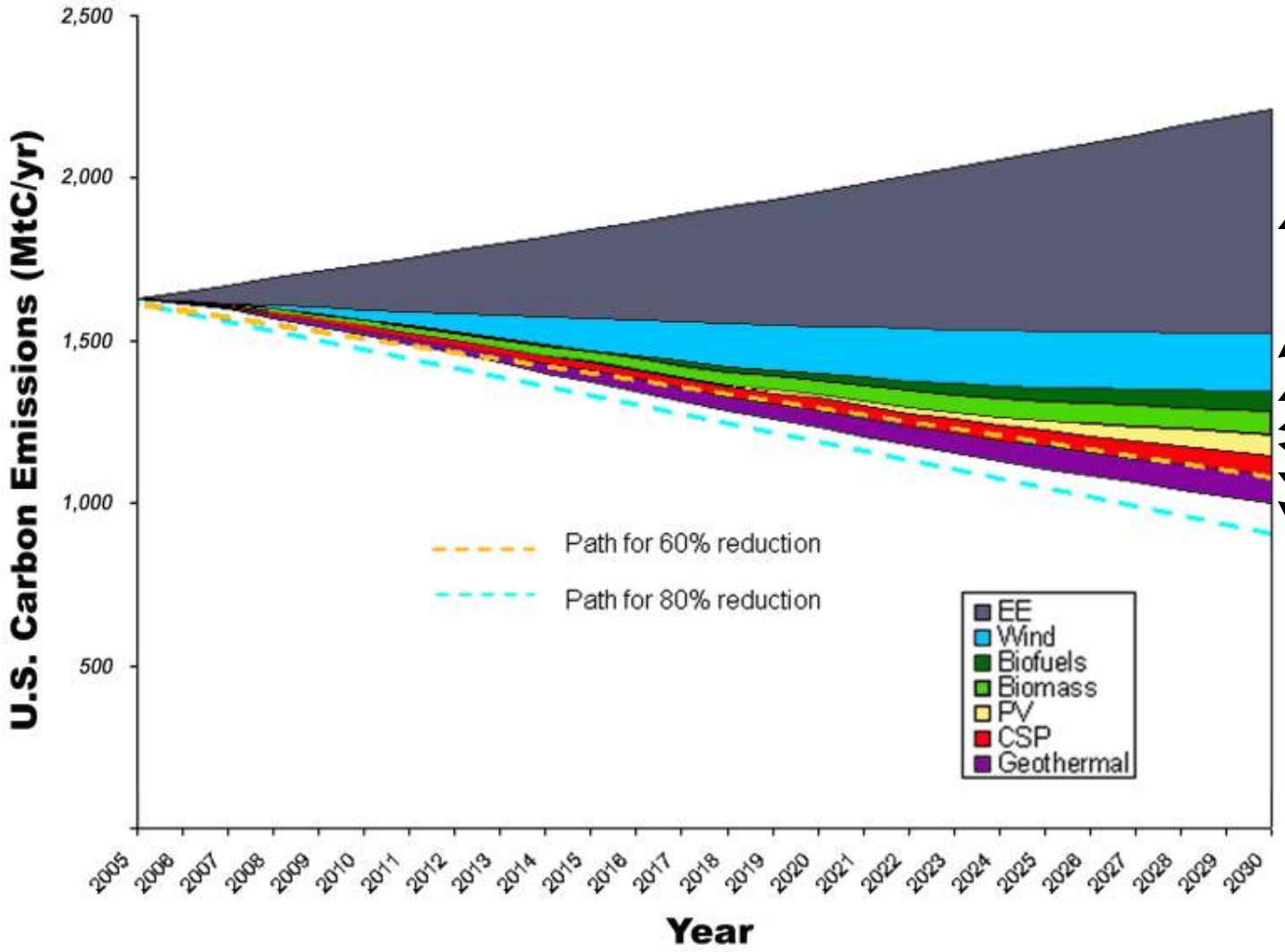


U.S. Carbon Emissions Displacement Potential from Energy Efficiency and Renewable Energy by 2030



What does it cost?

-$108B/yr

$0B/yr

$9B/yr

$3B/yr

$5B/yr

$7B/yr

$2B/yr

Total:
Savings of $82B/yr

57% Energy Efficiency, 43% Renewables

U.S. Renewable Electricity Generation in 2030

Technology	Percent of Grid Energy in 2030
Concentrating Solar Power*	7
Photovoltaics	7
Wind	20
Biomass*	8
Geothermal*	9
Total	**51**

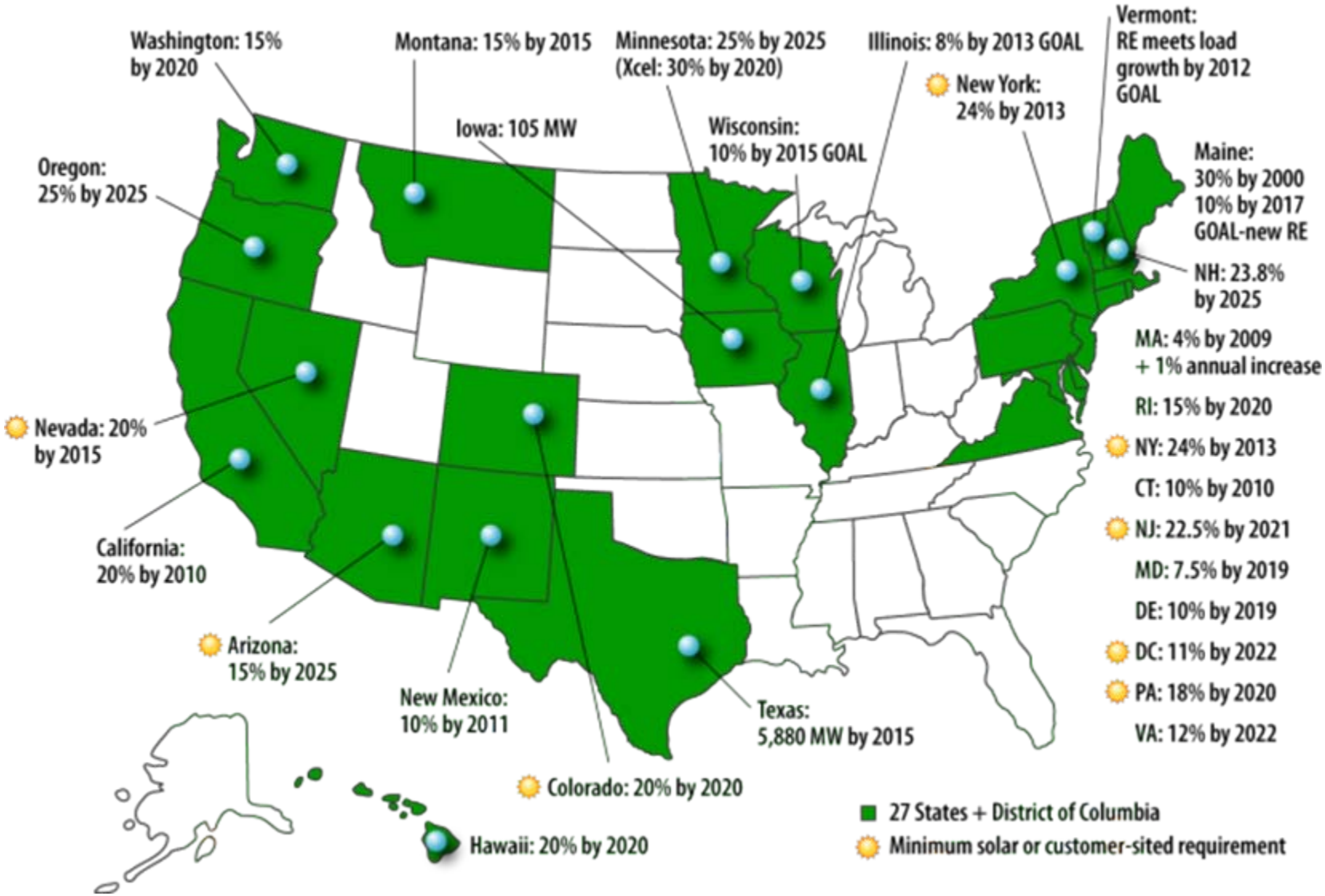
*Can provide baseload or near-baseload power

Impact of 20% National RES

Source: UCS

- 185,000 new jobs (3X fossil)
- $66 billion in new capital investment
- $25 billion in income to farmers, ranchers
- $2 billion in new local revenues
- $30 billion in consumer savings (by 2030)

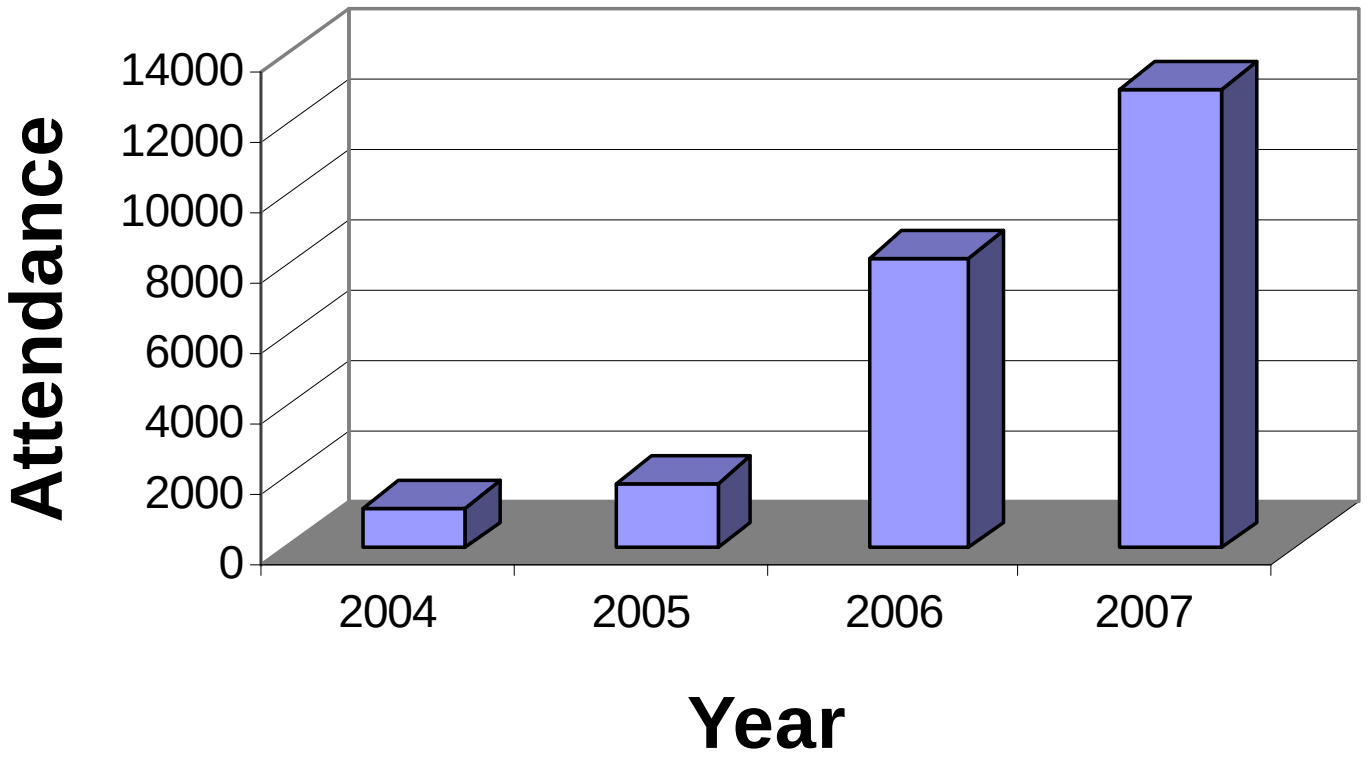
State Policy Framework
Renewable Electricity Standards

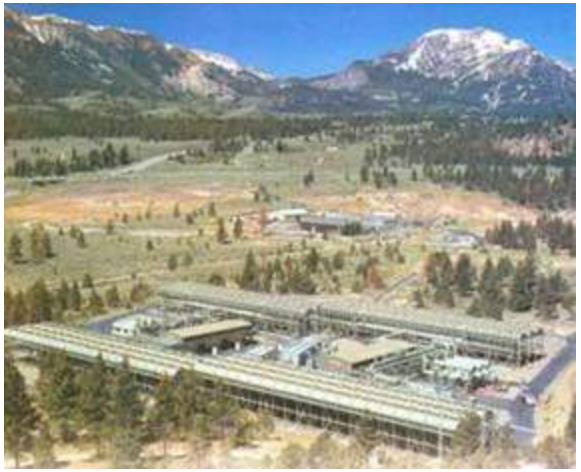


Source: DSIRE database, July 2007

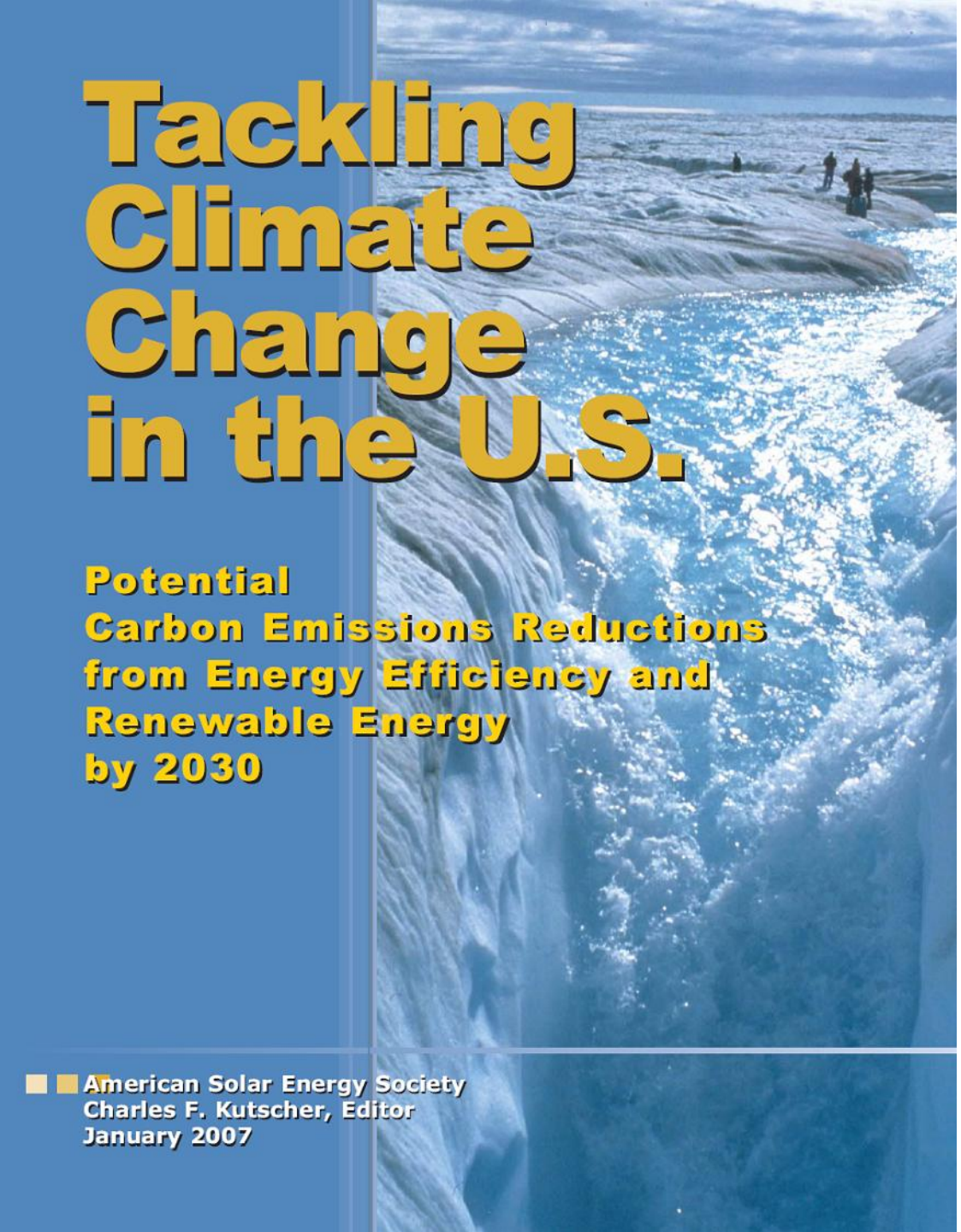
The renewable energy industry has taken off!

Annual Solar Electric Power Trade Show and Conference





A suite of clean, sustainable solutions



ASES report released Jan. 31, 2007

Available at:

www.ases.org/climatechange

Adopted by Sierra Club as their "energy roadmap"

For more information:

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Honaunau Bay, Hawaii, 11-26-07